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WILDLIFE HABITAT RESEARCH NEEDS IN SOUTHERN FORESTS

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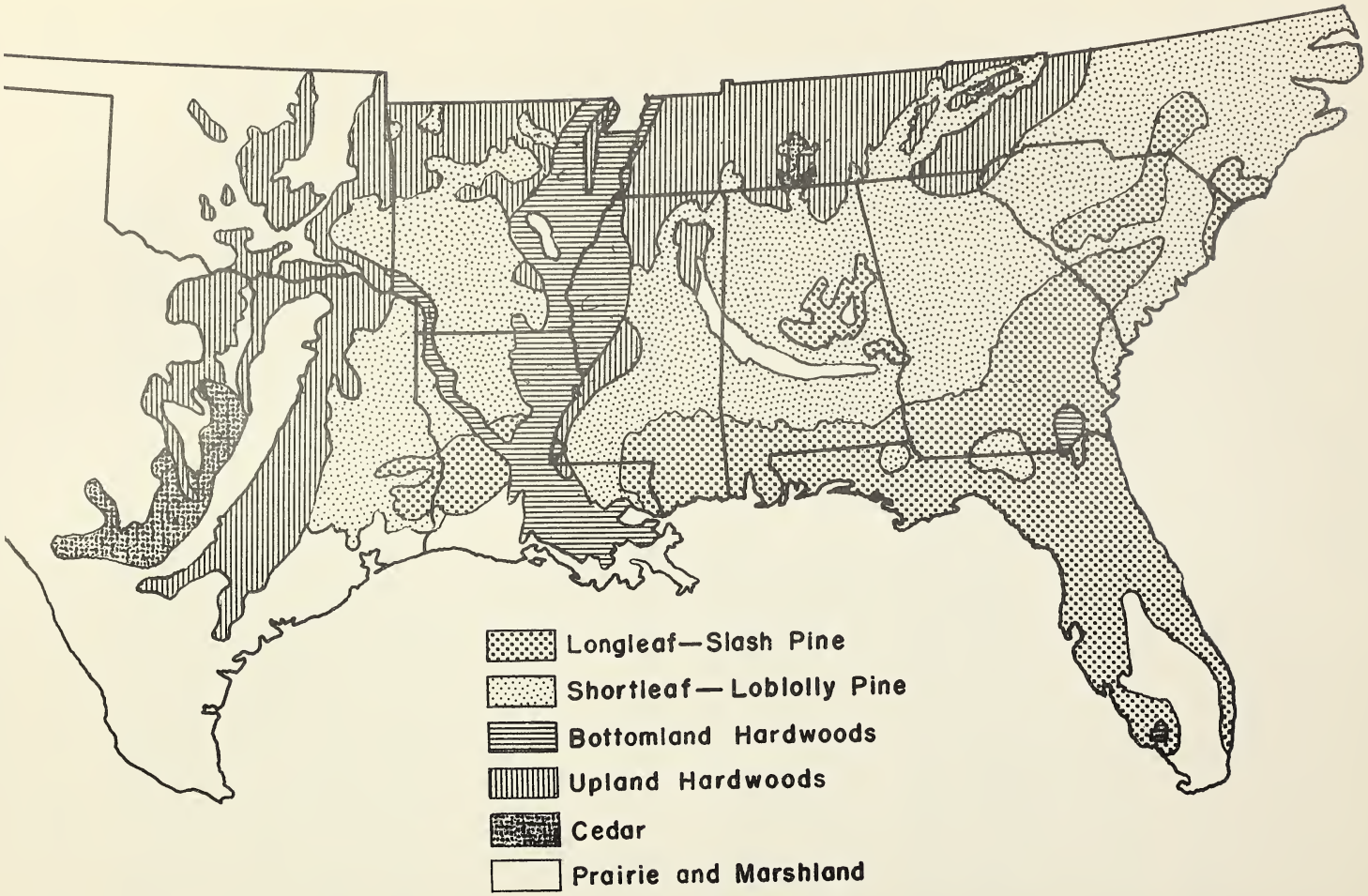

Figure 1.—Major forest types in the South.

Foreword

The purpose of this paper is to define the aims and tasks of research directed at improving the wildlife habitat on forest lands of the South. The research needs were determined by a review of literature pertaining to wildlife and its habitat, especially in the South, and by discussions with wildlife technicians, foresters, faculty members of schools having wildlife in their curricula, and sportsmen.

The review and the discussions emphasized the primary need for a better knowledge of the habitat. Information is particularly lacking on the effects of silvicultural practice, season, soil differences, and animal use on the volume and quality of food plants within the major forest types. Repeated stress was placed on the need for silvicultural modifications that would benefit wildlife, and also on the desirability for wildlife management techniques that would be compatible with silvicultural requirements. Timber harvesting methods, timber stand improvement practices, and the use of special measures to provide wildlife food and shelter are the phases of integration of wildlife and timber management that were considered to be of greatest importance.

Following the problems of habitat analysis and of integration of wildlife with timber management are others which may be very important in some areas and of less consequence elsewhere. These are competition between various species of wildlife, and between wildlife and domestic livestock. There are also problems of forest lakes and streams as well as those special problems of food and cover pertaining to a single species.

The most important forest game species in the South are deer, squirrels, and turkey. However, raccoons, foxes, opossums, and the European wild boar are also important in some localities. Quail, doves, wood ducks, grouse, and many other game birds use the forest lands also. Besides these game animals and birds of interest and value to hunters, there are others such as song birds, hawks, flying squirrels, and armadillos which, although not bagged or trapped, make a valuable contribution as a part of the community of living things within the forest. Some of the problems relating to these are briefly listed.

This paper does not attempt to specify studies to fit local conditions. Rather, a brief presentation is made of some past and present work pertaining to the broad problems. There is some discussion of the problems as they affect the wildlife habitat, and recommended lines of inquiry are summarized.

WILDLIFE HABITAT RESEARCH NEEDS IN SOUTHERN FORESTS

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THE NEED FOR FOREST WILDLIFE HABITAT RESEARCH IN THE SOUTH

The forests of the South[1/] contribute a major share of the raw materials that form the basis for the region's industrial growth and prosperity. Forests also protect the watersheds, are an integral part of the scenic beauty, and provide the habitat for an abundance and variety of wildlife.

All of the 181 million acres of forest land in the South support some form of wildlife. Game has increased and is continuing to increase rapidly in numbers (113)[2/]. Since only about 17 million acres of the forest land are in State or Federal ownership, this game will occupy more and more private forest land. More than 90 million acres of the private forest are on farms. The farm forests are very important for squirrels and other small game, but they are often too small or too close to human habitation to attract larger game. The bulk of the increase, particularly of deer and wild turkeys, will therefore be found on larger tracts of private forest--the lands of greatest value for commercial forest production and the most likely to be under intensive timber management.

With the forest coming under increasingly intensive management, the cost of every process of timber production is carefully watched[3/]. Costs and returns of wildlife production will also have to be accounted for. Or if returns cannot be accounted for accurately, it should at least be possible to establish the cost of the timber-management alternatives that create conditions favorable to game.

1/ The area considered includes Arkansas, Louisiana, Tennessee, Mississippi, Alabama, North Carolina, South Carolina, Georgia, Florida, eastern Oklahoma, and eastern Texas.

2/ Underscored numbers in parentheses refer to Literature Cited, p. 48.

3/ Includes sawtimber, pulpwood, and other products.

Modern business methods demand precise and quantitative measures of the habitat and of the results of management on costs and return. Costello (55) says, "A sound method of judging the range [habitat] must have an ecological basis. It must recognize the structural characteristics of plant communities, characteristics which are susceptible to measurement as well as qualitative description. It must recognize the dynamics of vegetation and therefore range trend, which can be measured in terms of change in structure and yield over varying periods of time. It must recognize the physical environment which includes climatic, edaphic, pyric, and biotic factors including animals and man; and it must recognize practical use of the multiple products of the land on a sustained yield economy."

The need for accurate, quantitative, businesslike methods of coordinating wildlife with timber management has arisen because increased human population, industrialization, greater income, and more leisure have greatly intensified the demand for recreation and hunting. The public wants more wildlife and it reserves the right to regulate, or fail to regulate, wildlife numbers. As game is public property, even though produced on private land, there is bound to be some conflict of interest between the landowners and the hunters.

To prevent an impasse in one instance, Kitchens (126), representing the Louisiana Forestry Association, suggested that Louisiana timber and game interests get together and work out mutually acceptable solutions. The Forestry Association made a survey of its membership, which represents the greater portion of the commercial forest operations in the State. Out of 52 forest landowners making returns, two were very interested in developing wildlife habitat on their own lands, 45 expressed some degree of active interest, 4 were not interested, and one was opposed[4/]. Thirty did not reply. The interest expressed by those answering is more than lip service, for 18 of the companies reporting now have wildlife refuges, 39 are willing to have refuges, 20 now make some provision for leaving game food trees, and 25 would be willing to give game food trees some consideration. This report might be assumed to represent a fair sample of the opinion of the larger forest landowners in the South.

In attempting to coordinate the production of wildlife with that of timber, two questions face the owner of forest lands. These are: (1)

4/ Sentell, N. W. Unpublished report presented to a joint meeting of the Louisiana Forestry Association and the Louisiana Wildlife Federation at Baton Rouge, Louisiana, February 1, 1956.

What adjustments in timber growing practices are required to improve and maintain wildlife habitat? (2) What will be the effect of these adjustments on the costs and returns of timber production?

In addition, there is the problem of competition by game and livestock for forest grazing 5/. Almost all of the forest land on farms and much of the other forest is grazed by livestock. Game-livestock competition must be studied to determine the amount of grazing that the forage 6/ can tolerate.

Finally, on areas set aside primarily for game, there is the problem of improving game range through such measures as artificial regeneration of important food species, establishment of food plots, burning, artificial provisions for nesting or denning, or special methods of cutting timber.

Large-scale trial-and-error attempts to improve the forest habitat are likely to be costly. Carefully planned studies on a small scale should yield valuable results at much more reasonable cost. The interactions between timber, livestock, and game call for coordinated study by foresters and wildlife biologists--by foresters on habitat phases and by biologists on animal phases. For example, the development of timber stand improvement rules is a task requiring both foresters and game technicians. Because game is the property of the States, State game departments and universities should assume the lead in wildlife research.

5/ "Grazing" is more often used to describe plant use by domestic livestock. Biologists usually use the term "browsing" to describe use by deer. However, sheep and cattle both use browse in addition to grass. Grazing is used in this paper to indicate both "grazing" and "browsing."

6/ As used in this analysis, forage means the browse, forbs, and grass used by deer and domestic livestock. Wildlife food or game food includes fruits, nuts, etc., as well as forage.

ANALYSIS OF THE FOREST WILDLIFE HABITAT

Need for Analysis

Habitat is a composite of all of the elements of the landscape over which an animal ranges. It consists of the climate, the altitude, the topography, the soil, the water, the vegetation, and all the results of occupation of the land by animals and man.

Climate and altitude are relatively uniform over the South, but topography must be considered locally as it affects vegetation and its use. Soil quality is reflected in the volume, composition, and nutrient value of vegetation. Because plants furnish the food and much of the cover for wildlife, research into the factors affecting survival and growth of food-producing plants and communities is the means by which optimum wildlife habitat management methods may be most quickly developed.

Since vegetation is so important a part of the habitat, management methods must be developed that will preserve the volume, quality, and reproductive ability of the vegetation through the most critical part of the year as well as through critical portions of climatic cycles. Grange (103) says, "Over and over again we must come back to the central theme of game management, namely that preservation of the vegetative habitat is the first, basic, all-important step to be taken." Show (188) says, "Food of acceptable kinds and in adequate quantity does not always determine the area or the capacity of an area for occupation by a particular species. A species requiring dense cover for escape, roosting, and nesting, can make no use of a food supply located in an exposed area into which it dares not venture. The valley quail's feeding, for example, is ordinarily restricted to an area within 100 to 150 feet of its escape and resting cover. The cottontail, except sometimes at night, ventures only a short distance into open areas. On the contrary, species depending on speed rather than cover for escape have large feeding areas available to them."

The failure to have a desired species of game or the desired numbers stems from some limiting factor of the habitat. Taylor (201) restates Liebig's Law of the Minimum in relation to this problem: "The growth and functioning of an organism is dependent upon the amount of the essential environmental factor presented to it in minimal quantity during the most critical season of the year, or during the most critical year or years of a climatic cycle." In further pointing out the importance of studies of long enough duration to test the critical conditions existing during the extremes of climatic fluctuation, Taylor (201) states: "Since details of the influence of extreme and intermittent conditions would often be entirely missed by short-period observations of experi-

ments, the desirability is obvious of long-time research projects.... Land-use policies, range administration, forest conservation, and game protection should be adjusted not to average conditions, but to those poorer than average, if not to those that are extreme."

Productivity and Nutrient Value

Understory vegetation varies considerably among forest types. Within each forest type the structure of the timber stand varies with site, composition, and past management. Some stands may be fairly light but so evenly spaced as to shade out understory plants, while a much heavier stand irregularly spaced might allow a substantial amount of forage to exist. If wildlife management is to be planned concurrently with forest management, the relation of timber-stand structure 7/ to wildlife food production and quality must be known and its variations measured within each of the major forest types.

As the timber grows, light and moisture conditions on the forest floor change and the habitat may alter markedly, so that the area is occupied by a succession of different animals suited to the conditions present at the time (103). This circumstance illustrates the need for study of the structure of the timber stand and the results of its variations in terms of forage production. Only when information on these subjects has been secured can game forage production be properly fitted to the general land management plan.

Read (172), working in the Ozarks, found that the amount of forage under a hardwood stand decreased from 600 to 100 pounds per acre (green weight) when the overstory increased from 50 to 375 trees per acre (over three inches d. b. h.).

Gaines, Campbell, and Brasington (83), in a study of forage production on longleaf pine lands in southern Alabama, found that forage varied from about 1, 000 pounds (air-dry) per acre with no overstory, to 400 or 500 pounds per acre where the basal area of trees was about 110 square feet. From this low point, forage increased to a little over 500 pounds per acre at a basal area of 150 square feet per acre. This was due to the fact that longleaf pine stands open somewhat at maturity, allowing more light to reach the forest floor.

7/ Timber stand structure is a term used to indicate the composition, height, basal area, and distribution of trees over an area.

Martin, Dunkeson and Baskett (146), in the Missouri Ozarks, found that forage varied inversely with crown cover and that forbs made up the majority of the forage. They also found that "good" forage species increased most with release.

Campbell and Cassady (45), working in Louisiana on pine-bluestem ranges, found that green succulent forage is high in crude protein, while matured, weathered, and dry forage is low.

Other qualitative analyses of livestock and deer forage have been made and sufficient information is available to evaluate a few of the more important plants and to give some indication of the effect of the forest and of grazing upon them (24, 44, 47, 48, 49, 50, 67, 81).

Campbell and Cassady (47) found that the herbage production was higher under hardwood than under pine stands because pine litter built up much greater weight than hardwood litter.

Einarsen (77), in Oregon, found that, as the timber stand closed, less nutritious foods were produced.

Within all types and range conditions, season exerts a strong influence upon productivity and nutrient value. Careful consideration must be given to these seasonal variations, for as the growth of forage decreases with the passing of spring and early summer, the nutrient value and palatability of many of the staple forage plants also decrease. This decrease is illustrated by the studies made by Campbell and Cassady (47). They found that in central Louisiana crude protein in the range cattle diet gradually decreases from a high of about 13 percent in April to a low of less than five percent in December and January.

On the Pisgah National Forest in North Carolina, on deer range that had been seriously damaged by overstocking, recovery was non-existent or extremely slow under a closed canopy of trees. Competition for space and light by the timber overstory apparently retarded establishment of ground cover to such a degree that a very few deer prevented the reproduction of any significant amount of forage (34).

Openings and edges are one phase of timber stand structure which have received considerable study. Game animals thrive best when openings in the forest are frequent and large enough to allow for the growth of shrubs, herbs, and other food plants. Gysell (105), in beech forests in Michigan, observed that understory vegetation was absent in many interior areas, that borders had more species than openings, and that species on borders and in openings were generally not the same.

A group of foresters, wildlife biologists, and range men, studying forage conditions on the Ouachita National Forest in Arkansas in 1955, found that in areas of heavy canopy cover many plots contained no forage plants. Large openings, overgrazed in previous years, were occupied by grasses and weeds not relished by livestock. Small openings and the edges of large openings contained heavy growths of shrubs and such game food as smilax, grape, and various herbs.

Barick (20), in New York, observed that there was an "edge" effect between forest types and that there was a greater variety of understory plants near the type border. He also observed that the understory plants were different under different forest types.

Some plants are important to livestock as well as to many species of wildlife. Others, not very palatable to domestic livestock, have escaped heavy grazing and form an important part of the wildlife diet. Martin, Zim, and Nelson (147) list several upland grasses and herbs in this category, among them panic grass, bristle grass, ragweed, paspalum, crabgrass, and some of the sedges.

Mast-producing plants are also important to a wide variety of wildlife. The chestnut, once probably the best common source of wildlife food, has disappeared but some efforts to establish Chinese chestnuts have been successful, even though this chestnut is very limited by its soil requirements. Diller (70) describes a 12-acre, 55-year-old, plantation of Chinese chestnuts in Virginia which has been highly successful and provides "the best squirrel hunting in the county."

Since trees like the Chinese chestnut have little timber value and are limited by soil and moisture requirements, perhaps their best use is as food trees on other areas devoted primarily to wildlife.

Fruit-producing plants are particularly valuable both to birds and animals. Blackberry, wild cherry, grape, blueberry, persimmon, cedar, and hackberry are among the most important, but little is known of their actual production and contribution to carrying capacity.

Oaks have been the most important mast producers since the disappearance of the chestnut. They are perhaps the only woody plants that are used by all classes of wildlife in the southeastern region (147). Van Dersal (210) states that 94 kinds of birds and 92 kinds of mammals use the oak. Christisen and Korschgen (53) report that the yield of oak mast is a determining factor in the size of the squirrel crop of the following year. Because of the importance of oaks in wildlife management, some of the information about acorn production will be summarized.

Acorn fall begins in August or September and lasts until December or January. Individual trees not only vary widely in production from year to year but also in time of acorn fall. The larger, more mature trees with well-developed crowns are the best producers (38, 52, 53, 57, 58, 72, 74, 100, 123, 152, 153, 164, 210). Variations in mast production have not been accounted for by the studies made thus far, and there is some likelihood that genetic influence may have a dominant effect upon acorn production.

Some of the oak studies contribute to the knowledge of acorn utilization. Kautz and Liming (123), in Missouri, found but 2 percent of the acorns viable by March. Moody (152), in Louisiana, made cutting tests covering three years, 1950-1952, and found blackjack oak to vary in soundness from 34 to 49 percent, bluejack from 48 to 63 percent, and post oak from 24 to 100 percent. Burns, Christisen, and Nichols (38), in Missouri, found that less than one-half of the mature acorns were sound when collected during the period of seedfall and that post oak produced few sound acorns. However, Goodrum and Reid (99) observed that quail and squirrels eat weeviled acorns for the weevils as much as for the nut meat. Kautz and Liming (123) found that insect-infested acorns were taken in preference to sound ones.

White oak in the Missouri Ozarks yielded as many as 5,300 acorns per tree and averaged 700 to 1,100 acorns per tree (38, 152). Downs (72), in the southern Appalachians, computed the average in a 7-year study of white oak mast crops to be 18.7 pounds per acre. He later found that stands that have been cut heavily may yield 100 to 150 pounds of acorns per acre (173). Dalke (58), in Missouri, estimated the average of a two-year crop equalled 21 pounds per acre, with 166 acorns per pound. Burns, Christisen, and Nichols (38), in Missouri, found 188 white oak acorns per pound, and on black oak an average of from 900 to 1,500 acorns per tree. Christisen and Korschgen (53) estimated that a hypothetical stand of 20 oaks per acre would yield 20 pounds of acorns per acre. This would be 1 pound per tree on the average.

Southern red oak was found to be a low producer in Goodrum's study (100) in the scrub-oak type on longleaf pine lands of east Texas. However, small trees were all that were available in this study area.

Post oak averaged 200 acorns per tree on two Missouri sites described as slightly below average for oak (38).

One of the foremost needs in determining the productivity of wildlife habitats is an accurate method of sampling the production of mast-bearing trees. Gaiser (84) has described a method of sampling circular plots which may aid greatly in measuring the production of a single tree. Even when productivity has been determined, it is still difficult to convert the data into animal carrying capacity; present methods give only rough approximations. Yield figures may be strongly biased by the procedure used to select individual trees for study and by the method of putting the results on an acreage basis. Methods of measurement are needed not only for oaks, but for trees such as dogwood, mulberry, and other important fruit and mast-bearing species.

The management of game food is so intimately tied to a tree overstory that it is also necessary to know how palatability, succulence, and nutrient content of game food vary with stand structure as well as with other factors (127). In the evaluation of forage a technique is needed which will permit the assignment of a numerical value to the balance of nutrients contained in a given quantity of forage (148).

In sum, the principal tasks of research in respect to productivity and nutrient value of game foods are to provide techniques for measuring the usable volume, nutrient value, and seasonal variation of game food in relation to forest type and site and to relate these to game management objectives and silvicultural practices.

Condition and Trend of the Vegetation

The study of both livestock and big game grazing in the United States began in the West, and most of the ecological concepts and terminology have been developed from western conditions. These terms and concepts can be applied in the South with the necessary adaptations which must be made for difference in vegetative type and rainfall. In the arid and semi-arid West, the animals use a plant community complex that is composed of a combination of open grassy "park," timber, and desert or mountain brushlands. The composition of these communities may vary but the boundaries of the communities do not change rapidly. Over most of the West the original climax vegetation is used as the standard from which to judge the current plant community, even though the vegetative cover sought in management is not the climax. On California range lands an annual community made up largely of exotic species is the base for management.

In the South, practically all forest grazing is influenced by timber because open grassy "savannahs" and brush areas are for the most part transitory in nature. With the expansion of scientific management in forestry, "climax" or "stage of succession" may not be the most useful standard for judging the condition of the current plant

community. A thorough understanding of the natural trends in vegetation, however, is necessary to evaluate the range condition.

The term "range condition" (state of health or productivity), when applied to the forested game-livestock ranges of the South, also contains elements dissimilar in emphasis to the same term as used in the West. In the West, range condition is primarily the result of the pattern and intensity of grazing over a period of years. In the South, the range condition also is greatly affected by the pattern and intensity of grazing but it may be primarily affected by the composition, density, pattern of occurrence, and height of the forest overstory, or by fire. Shade may often have more influence on the vegetation than does utilization by animals. Therefore, range condition cannot be judged by "climax" vegetation. Instead, evaluations must be based upon the composition of the forest understory as it changes with the development of the timber stand under management.

Some work has been done to ascertain the composition of plant communities in a few forest types. Notable studies are those by Ruff (177) in North Carolina, Harlow (110) in Florida, Lindzey (140) in Oklahoma, and Goodrum (90, 98) in Alabama, Mississippi, Louisiana, and Texas. These studies list key browse species and give an estimate of the proper degree of utilization, but they do not describe the forest overstory or the understory plant community in sufficient detail to be useful in determining the range condition or indicating its trend. In order to establish standards, an analysis and description of the plant communities under different forest types and stand structures is needed. Research must determine the ecological relationships and standardize descriptions which may be used as guides for establishing the carrying capacity of the range.

Productivity and nutrient value of the food plants indicate the maximum carrying capacity of a range. Other factors limit the actual capacity to numbers below this maximum. Social behavior limits the numbers of some animals to a density well below what would be indicated by an inventory of the food (101). Need for cover, as with rabbits or quail, or for open areas, as with turkeys, causes a large part of the food to be practically unavailable.

Improper distribution of grazing also limits carrying capacity. McIlvain, Baker, Kneebone, et al. (149), working with livestock on the Great Plains, found that livestock did not graze uniformly even on very uniform pastures containing but a few hundred acres. Securing uniform utilization is much more difficult in mountainous regions like the Ozarks or Appalachians, or in areas containing heavy timber. Varying

patterns in use of range by both deer and cattle have been recognized for many years and the problem of obtaining better distribution continues to be a major one.

Preference of animals for certain foods also must be considered in estimating proper range use. Food preferences not only change seasonally, but preference for the same plant often varies from place to place. Also, animals frequently use plants that are less nutritious than others that are available. Preference for food plants by deer has had considerable study and reports are available for several of the more important deer ranges in the South (40, 60, 64, 71, 90, 93, 98 106, 128, 132, 140, 168, 172, 177).

Seasonal availability further limits the carrying capacity of a range. The quantity of wildlife food, and the nutrient value, must be determined for the critical season. The critical season may be late spring in the colder portions of the region as the Ozarks or Appalachian Mountains, or it may be the summer months in drier areas like eastern Oklahoma or Texas.

The necessity for knowing the carrying capacity of the range, especially for deer, cannot be too strongly emphasized. If the deer exceed the capacity of a range and starve, they so thoroughly destroy the food plants that it may take decades for the range to rebuild sufficiently to support its original population. Leopold, Sowles, and Spencer (139); Hahn (106); and many others have studied the effects of starvation on deer range. Overgrazing by deer leaves the range in such serious condition that one of the most important problems of wildlife habitat research is to develop procedures for evaluating and describing trends in the condition of the range in time to prevent permanent harm.

"Trend," as well as "range condition," has a different connotation in the South than in the West, although the same principles apply. In the West the term generally indicates whether the plant succession is moving toward or away from the climax cover (178). In the South, the trend will be toward or away from the forest understory typical of a certain forest stand structure.

A knowledge of the degree of utilization that can be made of key forage plants by both deer and livestock is very important, for it is these key species, highly palatable to both deer and livestock, that give the first indications of range trend. Julander (122) found that forbs made up a high percentage of the deer diet regardless of other forage present and that the condition of the range could best be determined by observing forbs and browse species used by both deer and cattle.

Figure 2. --White-tailed deer can become so numerous that they damage forest reproduction, overgraze the range, and destroy forage reserves needed for the breeding herd. (Photo by Texas Game and Fish Commission)

Ruff (177) described key species and the degree of utilization allowable for the types in the Pisgah National Game Preserve in North Carolina. Goodrum and Reid (98) made observations on cattle utilization of key deer browse species in the longleaf-slash pine type in Mississippi. Goodrum (90) has also studied the effect of deer browsing in the longleaf-slash pine type in Alabama and (97) made lists of key deer browse species for Mississippi, Alabama, and Louisiana.

Utilization of forage varies with location and plant composition, and from season to season. Many technicians have concluded that deer use only few species, but a compilation of the key species reveals that deer eat a wide range of plants--although they may concentrate on a few in any one locality in a single season.

Among the most important studies needed are those that will indicate degree of utilization by seasons and by soil, forest, and forage types. These utilization measures should be sensitive enough to indicate trends before damage is done. From all of these, utilization standards for proper use of range for the various forest and forage types may be prepared (4, 5, 6, 11, 26, 40, 51, 60, 67, 71, 75, 85, 90, 93, 98, 104, 114, 128, 134, 135, 138, 140, 157, 162, 168, 177, 211, 214).

The requirements of the key forage plants for survival and their resistance to animal use is a most important factor in evaluating the trend of vegetation. Cassady (49), in Louisiana, made clipping studies to determine the effect of repeated harvesting on various forage plants. He found that while conservative grazing did not materially reduce bluestem grass production, the growth of broadleaved plants was

lowered by every degree of repeated harvest and to a much greater extent than that of grass. This explains why game range deteriorates so much more rapidly than cattle range. It may also point out why it has been so very difficult for people to grasp the vulnerability of game range to overgrazing, as they have become accustomed to the relatively high resistance of grass to grazing pressure. Lay (131) made clipping studies on five important deer browse species in Texas. Many more studies are needed on the effect of repeated harvest on important grass, forb, and browse species. Particular attention should be given to important legumes. Information should be obtained on the effect of repeated harvest of key plants at critical seasons. The effect of fire and other disturbing factors should also be studied.

Lack of knowledge as to the life requirements of key game-food plants also is one of the important deficiencies in the South. Expensive and often futile efforts are often made to keep wildlife areas in some stages of "primary" or "secondary" succession, while, if the requirements of the desired plants were known, it might be entirely practical to produce them by providing for their requirements in the timber cutting plan.

Not only must the plant's reaction to competition with trees and understory plants be determined, but the internal needs of the plant must be known. What are its moisture requirements? What conditions must prevail for a plant to develop viable seed? For the viable seed to germinate? What are its soil requirements if it is to produce fruit or palatable forage? What is its resistance to grazing? Many writers speak of the importance of wild grape to deer, turkey, or raccoon; but a thorough search of the literature revealed no information on the life history or requirements of the wild grape. The same situation exists with most other wildlife food species.

Such studies as were begun on bitterbrush (an important game species of the brushlands of California and other western states) by Hormay (118) are needed for the important game food species of the South.

The use of fertilizer to provide for certain physiological requirements and to stimulate production, nutrient value, or palatability of desired foods also should be investigated. For example, Bentley and Green (25) found that native clovers on California foothill ranges were stimulated by sulfur-bearing fertilizers.

Range Measurement Techniques

One of the primary research goals is to furnish administrators with accurate, ecologically sound, sensitive, but practical and rapid means of measuring the productivity, condition, and trend of the southern ranges. It may not be necessary to develop new methods, for methodology has been carefully studied for many years, but some of the more successful methods will have to be adapted to wildlife ranges in the South.

Standard study methods such as species lists and stem counts will give the composition of the vegetation, and a quantitative measure in pounds per acre is available in the method described by Campbell and Cassady (45), which is an adaptation to southern conditions of a method used in the West (170). Some of the methods developed on western cattle and game ranges should be tested under southern conditions (66).

Quantitative studies of livestock forage in the South have been made, and a method of obtaining production in pounds per acre has been adapted to southern range conditions (45). This method has been tested for wildlife range and has proved to be satisfactory for inventory purposes (110).

Aldous (3) developed a useful method of determining utilization of browse on southern ranges.

The Three Step Method of determining range condition and trend was developed by Parker (165) in a cooperative effort between research and administrative technicians in the West. The procedure, which involves point-sampling on transects, was adapted to specific needs in Idaho by Sharp (187). Varner et al. (211) used the Three Step Method and formulated a detailed set of instructions for the analysis of the big game ranges in Utah. Further modifications have been developed and systematized for various conditions in the western national forests. This method should be tested for its adaptability to game range in southern forests.

The development of techniques for the study of food and forage plants provides the quantitative basis for other investigations and should be given the highest priority in the forest-wildlife habitat research program.

Requirements of Wildlife for Food and Cover

Each animal has more or less fixed requirements for food, cover, and space. Some, like the gray squirrel, the dove, and the coyote, have

rather wide adaptability. Others, like the turkey, eat a wide variety of foods but must have the relative solitude of larger areas of woodland to prosper.

One of the first things needed by the forester is the biologist's determination of requirements of the animals. Much work has been done for some major game species, notably deer, squirrels, and bobwhite. Much remains to be done with all forest-wildlife species in relation to their requirements in a changing habitat.

There is adequate cover for most animals in the South. Deer cover may need to be considered on some of the open longleaf lands, but by and large cover is probably a less critical matter than food.

The food requirements for deer have not been worked out for the South, but French et al. (82), in feeding experiments with penned deer in Pennsylvania, found that a 50- to 60-pound deer required about 3 to 4 pounds of air-dry feed (6,300 calories) per day. A 150-pound deer required 9,900 calories--the equivalent of 5 to 6 pounds of air-dry feed or 10 to 12 pounds of green forage. Varner (211), in Utah, estimated that a 135-pound mule deer eats 4.5 pounds of air-dry forage per day.

Further study of the nutritional requirements of deer is needed, particularly as to the response to changes in range condition, season, forest stand structure, and soil (157). Nutrient requirements are particularly needed in relation to their effect upon the breeding habits of the deer and upon the production, survival, and growth of fawns. Soil determines the type, size, and nutritional value of the plants which occur in a given locality (moisture relationships, although not dependent upon soil, usually can be correlated with it), and can therefore be used as an index of the wildlife habitat. Albrecht (2) says, "... different animals are in specific climatic conditions more because of the food produced by the soil, as developed by the climate, than because the temperatures and rainfall are more comfortable."

Crawford (56), in Missouri, studied weights of over 8 thousand raccoons in relation to soil. He found that the weight of the animals increased directly with soil fertility. "The fewest raccoons--as well as the smallest--were taken in regions of lowest soil fertility, in spite of the fact that the amount of forest cover and permanent water was greater here than elsewhere!" He also reports that on a State refuge where the soil fertility had been built up, 90 percent of the three-year-old does produced twin fawns. On a neighboring tract that was untreated, only 40 percent of the does of the same age-class produced twins. Leopold and Dalke (137) report that 79 percent of the wild

turkeys in Missouri are on one soil type, the Clarksville stony loam. A similar soil, the Clarksville gravelly loam, supports an additional 15 percent of the turkeys. Such close correlations indicate that the fundamental answers to many game problems are to be found in the soil. In studies of the distribution, numbers, reproduction, health, and utilization of food by game animals, soils should be given the greatest consideration (141).

The use of supplemental feeds, such as planted corn and winter oats, should be evaluated. It is necessary to know how much the supplemental feeding increases the yearlong carrying capacity of the range.

Other studies are needed to determine the importance of mast in the diet of deer, for the various forage types. Deer stocking must be based upon the forage, because mast production is too irregular (135); however, if studies determine that a certain quantity of mast is available each year, this minimum should be considered along with forage. Dunkeson (75), in the Missouri Ozarks, observed that penned deer ate more browse when acorns were not available. Mast may be an important conditioner for the breeding season, as it is one of the most important fall and early winter foods. Controlled studies are needed to determine, in quantitative terms, the difference in the size, health, and reproduction between does having adequate browse and acorns and does having adequate browse only.

The squirrels' need for certain food items and the amount required to sustain a squirrel through the year should be determined and translated to carrying capacity. While it is impossible with present techniques to determine actual squirrel population, it might be feasible to work out practical means of determining the carrying capacity even though actual stocking rate is in doubt.

The maximum density for squirrels under good habitat conditions has been estimated at two or more per acre by Goodrum (95) in Texas, at 1 to 3 per acre by Schwartz (181) in Missouri, and as high as 3.3 per acre by Baker (15) in Texas, while Trippensee (205) states that 0.51 to 1.36 per acre is about maximum in near-ideal conditions. Techniques should be developed to determine the cost of timber management adjustments to obtain the desired carrying capacity for squirrels. The effectiveness of the measures could be gauged from game harvest data. Without such quantitative data, there is no sound basis for this portion of the forest game-management plan.

Similar studies are needed in relation to den trees. It is much less costly to attach a den box to a sound timber-producing tree than it is

to leave a cull in the woods just for denning purposes. Den boxes have been effective in many instances (39, 112). The requirements of animals for denning should be investigated further and the costs of alternatives determined.

The requirements of wild turkeys are generally known, and perhaps one of the most important single steps that could be taken toward the restoration of wild turkeys in the South would be for the various States and other interested agencies to cooperate in mapping and classifying the potential turkey range. Pooling of the best information would not only stimulate interest in wild turkey restoration, but it would lay a solid foundation for research in turkey management in important forest types. Because of the close correlation between soils and turkey occurrence, soil types should be considered in such a survey.

Comprehensive ecological studies of the kind made by Uhlig (208) on the gray squirrel in West Virginia will lay the foundation for sound integration of forest and game management.

In summary, the land manager needs to know the type of habitat in which the various animals can prosper. Within these types he needs to know how much food is required by the various animals and the type of food needed by seasons. A knowledge of the cover that allows certain animals to exist is another necessity. The results of research into these problems should be expressed in quantitative terms so that the land manager can provide for desired species without sacrificing valuable timber growing space for food or cover that game does not use.

INTEGRATION OF WILDLIFE WITH TIMBER MANAGEMENT

An earlier section discussed the dominant influence of the forest overstory on forage. In the managed forest, this influence is manipulated through timber harvest, such as regeneration, intermediate, or other cuttings for income. The forage is also influenced by timber stand improvement cuttings and by special cuttings for such specific purposes as the creation of open areas and edges for game. Both of these latter types of cutting require investment. This section pertains to the application of some of these measures and to the problem of preventing game from unduly damaging the timber stand.

Timber Harvest Influence on Wildlife Food

Timber harvest is the most important cutting from the standpoint of game, for it covers virtually all of the forest, is self-supporting, and removes the greatest volume of overstory. Swift (198) says, "Cutting is one of the most important tools for creating wildlife habitat. It provides browse for deer, temporary openings for all wildlife, and starts a new plant succession on its course." On some areas in critical seasons, tops left by cutting provide excellent emergency food (79). Titus (203) states that openings resulting from tree harvesting provide "edges" that attract game suitable to that habitat. From empirical information, foresters and game men have worked out rules for timber cutting to provide for game food and shelter. The Forest Service has for many years used timber marking rules which provide for the leaving of den and food trees.

More recently, some of the national forests have made coordinated cuttings in which timber stands are cut commercially with game range improvement being given a high priority. Examples of such coordination are pulpwood cuttings on the Ocala National Forest in Florida; after the pulpwood is removed, a brush cutter is run through the area to knock down useless understory vegetation that would otherwise take over the site to the detriment of both timber and wildlife. The combination of timber cutting and brush chopping has greatly benefited the deer forage (195). On the Chequamegon National Forest in northern Wisconsin, small scattered timber sales are made in winter so that tops will be available to deer during the season of food scarcity (198). In Missouri, on the Clark and Mark Twain National Forests, shortened cutting cycles of 10 to 15 years are being used to improve turkey ranges (119).

Although wildlife technicians often cooperated in making the rules under which these cuttings were carried out, foresters and wildlife technicians alike feel that improvements in timber harvesting could be made that would be more desirable both to timber and to wildlife. In-

formation is not available to guide the proper coordination of harvest cutting and game production. Among the studies of highest priority are those that will determine the effects upon wildlife food of various silvicultural systems, rotations, and cutting cycles.

Timber harvest affects the wildlife habitat in other ways than by altering the structure of the stand. For example, logging roads and skid trails disturb the forest floor and may assist in the establishment of wildlife food--but they may also lead to erosion and pollution of water with silt. Studies are needed to determine the effects of logging upon wildlife habitat and to improve practices; the effects will, of course, vary with such factors as soil, topography, plant composition, type of product being cut, and equipment used (71, 79, 136, 169, 177, 194).

Timber Stand Improvement

Timber stand improvement has as its purpose the betterment of the future tree crop. It is accomplished chiefly, but not wholly, by cutting, girdling, or chemically treating trees that have no value for timber. In some timber types and stand conditions, the removal of such trees may reduce the amount of food available for some wildlife species. In other types, timber stand improvement may provide a greater volume and variety of food than existed previously.

The reduction in crown density may allow a heavier growth of understory vegetation to develop. Often this will be of very different composition than the original understory and with a corresponding change in carrying capacity. If timber stand improvement is applied where crop trees are not major mast-producing species, a problem arises concerning modifications that should be made to allow for game food and den trees. These modifications depend upon several factors such as the species of game to be produced; the timber types; the composition of the grass, shrub, and forb components of the vegetation, and the place of game in the management objectives. In any instance, careful study is needed to be sure that the effort is expended to improve the limiting factor in the habitat. If this is not done, expenditures which provide additional food will have as little effect as restocking game on an area where the habitat cannot support it. If, for example, there are less deer on an area than is considered desirable, and food is believed to be the limiting factor, it would be necessary to determine the critical season of the year and the type of food needed. If early spring is the critical season, the development of grass and clover along logging roads might be the answer, or the need could be for a larger amount of mast-producing trees left in the stand.

Sometimes, because of ill-informed but highly vocal pressure, foresters make provision for deer forage far in excess of the needs of the animals present. Studies by plant ecologists of forage composition, utilization, and relation of forage to timber stand structure will apply to this problem. In addition, the results of studies by the wildlife biologists to determine the general as well as the seasonal requirements of the animals must be obtained in order to integrate wildlife with the timber stand improvement practices in the forests.

Studies of timber stand improvement are essentially concerned with forest type, stand structure, and the evaluation of forage. Insofar as possible, therefore, such studies should be pursued in connection with going research on timber stand structure and of forage production, utilization, and condition. These studies should establish the levels of food required by seasons and the levels of food produced by the habitat and provide a basis for adjusting timber stand improvement practices to wildlife management objectives.

Special Measures for Improvement of Wildlife Habitat

On game management areas, multiple-use areas, or on game holms interspersed in a commercial timber stand, special measures for improvement of wildlife habitat may be required. Such measures include the use of special cuttings, fire, chemicals, supplemental food or cover, fertilizing, and artificial regeneration of desired plants.

Special cuttings have been used to a considerable extent to provide food for immediate use by deer and to induce sprouting. Buell (36), in North Carolina, found that dogwood cuttings made in March produced the biggest three-year-old sprouts. Brender and Nelson (30), working in Georgia, found that hardwoods varied in their reactions when released by clearcutting an overtopping pine stand. Although the crowns of the released oaks and hickories grew larger, the number of trees did not increase.

Bryan (34) reported on special cuttings made on the Pisgah National Forest to provide food for deer on about 85,000 acres of deer range that had been destroyed by overstocking. Commercial clearcutting was used to obtain the maximum amount of food in the shortest time. This procedure obtained more food than could be used and forest reproduction was not satisfactory. Morriss (155) reported on additional work on the same forest when three areas were cut. One was clearcut at a cost of $42.82 per acre; here an excess of sprouts developed and very quickly grew beyond the reach of deer. The second area received a modified cut costing $16.33 per acre; and the third area, a commercial

sawlog cut followed by a timber stand improvement cutting. The third cut cost no additional amount for game. The usable browse was about the same in all instances, except that the sprouts grew out of reach of the deer quickly on the more open areas. In the second year, deer tended to stay near the edges of the cut areas, so subsequent cuts were made to obtain maximum edge.

Precise work is needed on the stages of succession following special cuttings and the cost of and amount of food produced by various methods. The studies should be correlated with timber type, stand structure, size and shape of openings, and soil.

Fire has for some time been recognized as a tool in game management, and has been used with varying results. Stoddard (192) wrote, "While the immediate and direct effect of burning an area is, of course, always apparent, the general effect of long-continued annual, or irregular but frequent, burning upon the vegetation of an area, and its indirect effect upon the animal life, presents a complex problem, one that would require years of careful research on the part of the personnel of a well-equipped experiment station to work out. Such research is greatly needed, and should be carried on, for fire may well be the most important single factor in determining what animal and vegetable life will thrive in many areas."

Grange (103) summarized the experiences of many men and years of observation in his chapter on "Controlled Burning for Game," when he noted the need for a better knowledge of plant succession and of the effect of intensity of burn upon vegetation.

Rosene (176), in South Carolina, reported that quail populations increased when fire was used to improve the habitat and decreased when no burning was done. Halls, Southwell, and Knox (108) found that certain combinations of burning and grazing increased broadleaved herbs. Campbell (43) noted that as burning decreased litter, a proportionately greater growth of both grasses and native legumes resulted.

Lay 8/, studying the effects of burning on key forage plants for Texas deer, observed marked differences in reaction of various food species to fire, both as to volume of forage produced and nutrient value. Three species decreased with use of fire, while some others increased. The study points out the need for further investigation of the reaction of key species to fire.

8/ Personal communication.

In the Appalachians, Jemison and Hepting (121) found that the damage exceeded the benefits, even in carefully controlled burning. Of the studies related to successional trends following fire, the majority have been concerned with grasses and other plants used by cattle and horses. Most of the research on use of fire has been in relation to timber management. The best field for studies of the response of wildlife food to fire will probably continue to be in connection with other studies of the use of fire in forest management. Some special studies of fire in the development of habitat may be needed.

Chemical plant-killers, now widely used in timber stand improvement, may also be valuable for managing wildlife range. Thus, selective herbicides might be applied to less desirable understory plants so as to make room for valuable forage species. They may be desirable when the vegetation to be killed is too large to be controlled by fire, or when burning would damage forest reproduction or forage. Chemicals are likely to be particularly useful in manipulating the vegetation on game holms.

Planting and seeding game food species has been studied by a large group, with notable results (10, 70, 76, 102, 133, 192). However, while most wildlife textbooks and numerous articles in farm magazines deal to some extent with wildlife plantings, the emphasis is usually on planting as a part of farm operation. Planting to produce forest game foods is not yet well understood. As has been mentioned, wild grape is a valuable game food, yet there seems to be no published information on artificially reproducing it on game ranges. In game holms, it may be desirable to kill undesirable trees and shrubs and to interplant desirable game foods. One possibility would be further work with Chinese chestnuts. Establishment of low perennial food plants along roads and rights-of-way should be studied. In those areas where mast has been found deficient or undependable, the selection and propagation of mast-producing plants should be studied. Ideally, such plants should be in the forest understory and provide a dependable crop of nutritious mast. They should be sufficiently fire-resistant to survive normal prescribed burns. All such plantings should be designed to increase game food during the critical season.

Special wildlife areas are frequently developed in the forest to improve game habitat. One of the foremost problems of forest wildlife research is to determine the size, location, and plant composition of such areas. Ideally, they would be stands of trees devoted primarily to wildlife, but with some secondary timber value, and the surrounding forest should have as much secondary wildlife value as possible.

The author has applied the term "holm" 9/ to these forest areas devoted to wildlife (37). Holms could vary from one-tenth of an acre to several acres, depending upon the species of wildlife sought, the limitations of the site, and the emphasis on game. A holm may be more economical of timber-growing space than the setting aside of a few trees per acre for "wildlife trees." Holms would not prevent the production and development of wildlife food and cover throughout the forest, but would provide areas that could be managed primarily for wildlife to supplement the surrounding timber stand. Some holms might be open, some might have food trees or shrubs of various species or sizes, and some might consist of mature mast-bearing trees. A combination might also be developed in a single holm. In the pine types, holms could be established in small bottoms and branch heads, as these are usually hardwood sites in which wildlife tends to congregate.

There are conflicting views as to the value of holms. Some biologists feel that they would concentrate the game and cause overhunting or overutilization of the food. Others feel that the holm is more adaptable to management than scattered trees and that, since animals would not be confined, holms would form valuable supplements to presently available game food. There is general agreement that such developments should be tested.

Fertilizer has had but little use in southern forests. Its ability to increase desirable wildlife forage should be investigated (151).

Wildlife Damage to the Forest

The very existence of the forest depends upon reproduction and growth of seedlings. Since neither good tree seed crops nor conditions for satisfactory germination and survival occur every year, the forest owner cannot tolerate any damage to regeneration (212).

Birds and rodents often destroy entire seed crops, while deer damage seedlings and young reproduction. The very important problem of protecting forest regeneration from seed-eating rodents and birds is the object of research now being carried on cooperatively by the U. S.

9/ This is an old Norse, and also old English, word for a small island; and the holm, as used here, is in a sense a wildlife island. The word also means low flat land near a river or a bottom. As these "islands" will predominantly be placed near small streams and branch heads, the author has taken the liberty of using a single word to replace a long descriptive phrase.

Fish and Wildlife Service and the U. S. Forest Service. Deer seek out and eat valuable species such as yellow-poplar even when other food is abundant. Some types of nursery fertilizer seem to give planted seedlings an irresistible attraction for deer. The author has seen deer eat every redcedar planted in an experiment and leave adjacent natural seedlings untouched.

In northwestern Montana, Neils, Adams, and Blair (159) found that browsing by deer is a primary limiting factor in pine regeneration. This same situation is noted in the South wherever deer have become abundant. To secure forest regeneration, management must protect critical areas by reducing or removing herds at critical times. The problem is obscured by sentiment, for once deer become established, it is very difficult to obtain public support for adequate harvest. If permission for an adequate hunt is granted, it is often difficult to get the hunters into areas at any distance from the road. Added access roads are being developed to facilitate hunting. In extreme cases, after an area is opened and the public given every opportunity to hunt, commercial hunters could be licensed to go into specified areas and, under close game-department supervision, remove a specified number of deer. This procedure would bring numbers down to levels that would protect the forest regeneration, preserve the forage, and ensure the continuity of a healthy deer herd.

The cost of applying deer repellents to extensive areas of tree reproduction is at present far too high to be of practical use.

The price of obtaining integration between wildlife and timber is coordinated management in which the forest gives way enough to allow the wildlife to survive and reproduce, and the wildlife in turn gives way to allow the forest to survive and reproduce. Research must provide the factual basis to guide management.

INTERSPECIES COMPETITION AND INTEGRATION OF WILDLIFE WITH LIVESTOCK GRAZING

Game animals compete with other wildlife and domestic livestock for the products of the forest range.

Bateman (21) summed up the problem of animal competition as follows: "Man's reaction to the consumption of vegetation on range or forest depends on his interest in the animals, in the material consumed, or both. .... If forests are to be grown, all efforts are directed to the production of a maximum yield of the desired trees. Wildlife, another crop from range and forest, is the chief concern of many people, most of whom do not live on the land. Quite often the owner of range cattle does not own the land and more generally those interested in wildlife production are not landowners. Thus, the forest and cutover lands of the South may be expected to produce one, two, or three crops by different groups, each demanding that his choice be given consideration. A better understanding of the interrelations between various types of animals and between those animals and the habitat is needed."

Taylor, Handley, and Pearson (200), speaking on the same subject, said: "Obviously the livestock cannot be removed or unduly reduced to make room for game; but in many places it is true that careful regulation of grazing will do more than anything else to promote soil and water conservation, improve returns from livestock, and build up wildlife as well."

In Louisiana, Campbell and Cassady (46) observed that cattle use considerable amounts of shrub and tree browse during the winter and early spring. Goodrum and Reid (97) found that in Mississippi cattle and deer prefer the same species of browse. Julander (122), in Utah, concluded that, "Competition between deer and cattle depends upon the extent of overlap of the areas grazed and on the forage preferences and supply of preferred forage in relation to number of grazing animals. If forage is plentiful, the animals are essentially not in competition for it. But as soon as overutilization of the important species begins, forage competition begins, and this affects management of the range."

Since deer compete with other animals for certain products of the range, it is necessary to determine the relation which domestic livestock and other wildlife should hold toward the deer herd. For example, dense thickets often preferred by deer are avoided by turkeys (71, 98, 106, 111, 136, 177, 189).

Moderate grazing by livestock and deer is not harmful to squirrels. On the other hand, overgrazing and trampling compact the soil, reduce

insect life, and make buried nuts difficult to recover. Wild hogs are a particular detriment, for they compete directly with the squirrel for food (15, 95, 165).

Research should provide techniques for measuring utilization of forage by deer and cattle and indicating proper range use on areas of competition.

PROBLEMS OF SOME IMPORTANT WILDLIFE SPECIES

Deer

The white-tailed deer is the most important big-game animal in the South. Although once seriously limited, it is now found over almost all of each State from North Carolina and Florida to eastern Oklahoma and eastern Texas.

The deer population has been rising rapidly over the past 20 years and now sufficiently large breeding herds exist to increase stocking rapidly up to or beyond the capacity of the range (19).

The normal breeding season of the white-tailed deer in the South is in the fall. However, observers have found young fawns at all months of the year (144). The gestation period is about seven months, with May and June being the usual fawning season. The condition of the habitat has a great influence on the breeding habits of deer and the number, health, and survival of fawns. Research must discover the condition of the various range types most conducive to the production and survival of a good fawn crop.

Deer use forbs and browse primarily, although they use some grass in the spring when it is succulent. The problems of deer range have been discussed previously but a few special ones will bear repetition in this section. One of these is the preference of deer for certain species (40, 60, 61, 68, 71, 90, 93, 98, 106, 128, 132, 140, 168, 172, 177). Though much information is already available there is still need for studies which determine the nutrients supplied by the principal plants and the species that indicate range condition under the different soil and forest types. Utilization and carrying capacity should be studied under controlled conditions with known numbers of deer in enclosures in order that accurate guides for stocking rates may be established (4, 6, 8, 26, 32, 51, 67, 75, 85, 104, 107, 135, 162, 186, 199, 211, 214).

Squirrels

Squirrels are among the most hunted game in the South. Goodrum (94, 95, 96) says that over 85 percent of the hunters hunt for squirrels. Hyder (120) reports over 2 million squirrels killed in Tennessee in 1954 and Redmond (174) states that 80 percent of Mississippi's hunters hunt squirrel.

The general distribution and the ability of the squirrel to stand heavy hunting pressure has preserved them, although they often become very scarce in some localities. Allison (9), in North Carolina, states that gray squirrels are declining because of persistent overshooting. However, the squirrel population rebuilds rapidly when the habitat is favorable and hunting pressure is relieved.

The most important squirrels are the fox and gray. There are many variations in these two species; for example, Louisiana alone has three geographic races of fox squirrel and two of gray, besides many color phases of each (125, 182). The red squirrel is also found in limited numbers along the northern border of our region (120). The fox squirrel prefers well-drained bottomland, hill land, and more open areas. It uses pine extensively. The gray squirrel prefers wet bottomlands and is a deep forest dweller, although paradoxically it is also the species that is usually seen in city parks (15, 22, 27, 94, 95, 96, 120, 174, 181, 185, 205, 207, 215). Oak, hickory, and other nut-bearing trees are important food sources and squirrel populations decline when these are destroyed (23, 95, 147, 173, 181, 185, 205). Determination of the number and kind of trees required to support a population of two or three squirrels per acre would greatly assist forest owners to plan timber management to accommodate squirrels. The location of the squirrel trees is also very important because of the preference of gray and fox squirrels for different habitat conditions. Perhaps a fruitful study would be to determine the requirements for red and gray squirrel holms for the different forest types.

In some areas, squirrels adapt their food habits to existing conditions. Terres (202) reports extensive use of elm buds by squirrels in Pennsylvania and New York. Parker (166) reports use of elm by Kansas squirrels but says that the animals do not remain long in pure stands of elm.

Trippensee stated in 1948 that no concerted effort had yet been made to manage squirrels intensively and his statement is probably still true. In general, good hardwood forest practice is favorable to squirrels because it encourages large trees and provides sufficient light in the

stand to stimulate mast production. Since the real requirements for mast are not known, it cannot be said that practices should be instituted to produce more mast in hardwood or pine-hardwood stands. In predominantly pine types, there are many areas where more mast may be needed and studies should be made to determine how to get a dependable quantity at the lowest cost in timber growing space.

Den trees are very important to squirrels, as each family needs more than one. However, when den trees are not available, leaf nests are used altogether (9, 59, 96, 174, 215). Den boxes, which have been successful in areas of high timber values, should be considered in terms of relative cost and effectiveness in relation to the leaving of den trees, which take up timber growing space. Butterfield (39) notes that some sportsmen's clubs in Ohio buy den trees for raccoons at a price that compensates the timber grower for the timber-producing space.

Uhlig's excellent work on gray squirrels (208) should be adapted to other areas of the South, and similar work should be done for the fox squirrel.

Rabbits

Cottontail rabbits are an important game animal, although more of a farm than a forest species. The cottontail is found throughout the South. Over 30 species and subspecies are listed. There are four species of swamp rabbits.

An abundance of rabbits is usually considered to be a detriment to forest reproduction. Plantings may be somewhat protected by the use of repellents on the planting stock (33, 56, 64, 103, 143, 145, 147, 163, 167, 183, 184, 205).

No research is recommended at the present time, but game holms developed for turkey or deer may also prove to be suitable for a limited rabbit population.

Turkeys

The wild turkey has six subspecies, but the differences between them are not important here.

Turkeys were originally found in 39 States. They ranged over most of the area from northeastern United States to the Great Plains and the Mexican border. At present, only 20 States have wild turkeys and the total number of birds is very low, although increasing in some places (13, 19, 29, 76, 205).

Recent publications report about 7 thousand turkeys in West Virginia and 45 thousand in Florida. Texas has the most, with 105 thousand reported in 1950. Although numbers were not given, 158 flocks were reported in Louisiana. About 7,000 turkeys were found scattered over 47 counties in Arkansas (13, 28, 89, 116, 117, 156, 213).

Much more turkey range is available than is now being used. About 20 million acres is present in Texas, where large ranches protect the turkey from poachers (161). In other parts of the South, national forests and game management areas, as well as land owned by private clubs, offer the greatest opportunity for preservation and increase of turkey range. Mosby (156) states that areas of unrestricted public hunting cannot support turkeys because of poaching by hunters of other game.

It is difficult to estimate the value of the wild turkey. In terms of meat, domestic turkeys are much cheaper and probably tastier. Edminster (76) says that the importance of the wild turkey rests on quality of sport rather than quantity. Stoddard (193), Gerstall (86), and most other writers agree that only the wildest strains should be used to propagate flocks and that management should be designed to promote wildness.

The nesting habits and the many sources of danger to nests and nestlings should be given special consideration in the management of turkey habitat. Because less than half of the nests are hatched successfully, an important field of study appears to be to discover the changes in the character of the habitat that would aid in increasing the number of successful hatches. Coupled with this would be studies of cover and food requirements as they are affected by the management of a timber stand. Many turkey studies have been made and there is a sound basis from which to work; however, most studies have been on areas devoted primarily to game production. Much additional work is needed to determine the needs and responses of turkey in forests managed for timber.

Turkeys avoid brushy areas and cultivated fields. They are adversely affected by reversion of land to broomsedge and by grazing. Turkeys require large areas not frequented by man. They need mature trees for food and some coniferous trees for shelter and often prefer coniferous thickets near streams as roosting places. Bottomlands are sometimes superior to more rugged areas as turkey cover. The location, management, and size of turkey habitat in commercial forests is a study that is needed before any considerable spread of turkeys to these areas can be accomplished (7, 13, 14, 62, 63, 65, 76, 88, 115, 116, 179, 191, 205, 209, 216).

Quail

Quail are normally farm-game birds, but in the South they are often found in the forest. Edminster (76) states that the loblolly pine woods are the best forest habitat for quail in the Carolinas. Goodrum (91) describes quail range in the longleaf pine woods of Louisiana many miles from human habitation. This range not only supported fair numbers of quail, but the cover was so good in the wiry grasses of the forest understory that hunting was difficult. Goodrum has also observed that quail make considerable use of pine seeds, apparently preferring the seed of the longleaf pine.[10/] In the discussion at the Fourteenth North American Wildlife Conference in 1949, he stated that more and more hunters are finding quail hunting a woods operation. Fortunately, work is now being done on the ecology of bobwhite quail on longleaf pine forest land.[11/] Studies of this type are needed as a basis for research work pointed toward the improvement of forest habitat for quail. For forest quail this is the most pressing research need, for other aspects of quail management have been extensively studied (22, 31, 42, 76, 91, 92, 99, 133, 175, 176, 192).

Woodcock

Woodcock is a shore bird that also uses the forest habitat. Preliminary work is being done in Louisiana to determine the life requirements of woodcock. St. Amant (190) writes, "Much more work is needed on this species before any management recommendations can be offered." In the formulation of programs of research and of timber management plans in the bottomland hardwoods and the pine-hardwoods, consideration should be given to the preservation of conditions favorable to the woodcock as rapidly as the biologists make the bird's requirements known.

References pertaining to woodcock include Edminster (76), St. Amant (190), Trippensee (205), and Wing (215).

Ruffed Grouse

The ruffed grouse is present in the Ozarks, in middle and eastern Tennessee (180), North Carolina, and the mountains of northern Georgia. Grouse need a combination of open lands, brush, hardwood, hardwood-

10/ Personal communication.
11/ By Phil Goodrum and Vincent Reid at Eglin Air Force Base in Florida, started in 1948.

conifer,and conifer forests. Second-growth slope hardwoods, mixed upland hardwoods, and hemlock-hardwoods are favorable sites near the northern border of this region (76, 109). Studies of the ruffed grouse in relation to forest types and forest management practices should be continued in order that fullest development of this superior game bird may be obtained.

Mourning Doves

The mourning dove of the Southeast is a prime game bird that requires fast, accurate shooting. The dove rivals quail as a dish and is sought by thousands of hunters. It uses the forest sufficiently to be considered with forest game in management.

Recently a Southwide study of doves was made by a cooperative organization of State, Federal, and private agencies that forms a model on which similar research can be patterned. Further dove research is under way using parts of the same plan (160, 171).

Ducks

Ducks use small lakes and ponds in the forest, and several species feed upon acorns. Wood ducks nest in hollow trees but will nest in boxes that are properly constructed and located. Pin oak acorns are most used by ducks but wood ducks also use acorns of the white and red oaks.

Wildlife habitat research in bottomland hardwood types should consider the wood duck. Christisen (52) and McLaughlin and Grice (150) are helpful references.

Foxes

Both the red fox and the gray fox range over all of the southern States. Foxes are abundant, but of little value economically--hides of red fox averaged 16 cents each and of gray fox 17 cents in Tennessee during the 1954-1955 trapping season (1). As an object of sport to the fox hunter, however, the animal is priceless.

The red fox dens more in the soil than the gray fox, but both use a variety of places including burrows, old slab piles, rocky ledges, and even abandoned buildings (197).

The food of the fox consists largely of rabbits, mice, other small rodents, and insects. Grapes and several kinds of berries and

plums form the main part of the vegetable diet (54, 78, 142, 204, 206, 216).

Numerous studies have been made to determine whether or not foxes prey upon quail and turkey sufficiently to be a major hazard to these game birds. Kozicky (129), in Pennsylvania, found no evidence of predation on wild turkey. Foxes eat some quail eggs and the birds also when they can get them, but the consensus is that they have but little actual effect on quail populations (142, 204, 206, 216). The problem of rabies becomes critical when foxes become overabundant, but trapping apparently will control this (217).

No research is outlined for the fox, but the effect of the fox as a predator or rabies carrier upon other wildlife species must be observed and, upon the recommendation of biologists, will need to be considered if habitat is a factor.

Raccoon

The raccoon has been found in every State in the Union but its range generally excludes the Great Basin and Northern Rocky Mountains (147). In recent years populations have increased astoundingly and many biologists believe that a cyclic decline will follow. In Missouri, 121 thousand raccoons were taken in 1952 (124). On one refuge in Alabama, the increase was so heavy as to make it desirable to harvest raccoons to prevent disease. Here over 2,000 raccoons were taken from 19,000 acres in a period of three seasons (12). A part of the increase in numbers has been ascribed to the decrease in pelt value. In Tennessee the pelts were worth but 54 cents in 1954 and 78 cents in 1955 (1).

The raccoon is omnivorous; acorns make up the largest part of their diet in season, with insects and crayfish following. Corn and fruits are eaten when available. The amount of animal matter in the diet has been reported from about one-third in some areas to about three-fourths in others, indicating probably both seasonal and geographic variation. Raccoons prey upon mice, rabbits, and other small animals and have killed sheep in Texas (18, 41, 87, 147, 196).

The raccoon seems relatively easy to manage, because he can defend himself, adapt to a variety of cover conditions, and eat almost anything. Den trees are a special need that should be considered, together with the possible use of den boxes.

There are at present no regional problems concerning the survival and maintenance of the raccoon. In research, the wide range of the raccoon, his omnivorous appetite, and his reaction to habitat conditions may make him a valuable animal for further work.

Opossum

Opossums range throughout the eastern United States, west to the Great Lakes, and south through Texas to Mexico and Central and South America. They are hunted as game, and sometimes used as food (possum and sweet taters). The quality of the fur and the price accordingly is low. In Arkansas the price ranged from 19 cents in 1940-41 to 60 cents in 1945-46 (116); hides were 13 cents in Tennessee in 1954-55 (1).

The opossum offers no problem at present, either as disappearing game, or as an important threat to other species.

Beaver

Beaver can become an important furbearing resource in the South. In 1941 over a thousand beaver were reported in Mississippi by Dearman (69). In a statewide survey of Alabama in 1939-1941, an estimate of over 3,500 beavers was made by Moore and Martin (154). Although not plentiful enough to be much of a problem, beaver have considerable effect on timber by cutting trees and by building dams that cause flooding of roads and timber.

No research is suggested at present. Research currently in progress on the effects of flooding of trees may be useful if this phase of beaver management becomes a problem.

Mink

Mink are present in all of the southern States, but not much literature is available on the forest as a habitat. Some consideration for the species may be necessary, especially in bottomland hardwood types.

Muskrats

Muskrats inhabit the coastal marshes primarily, although they occupy some areas adjacent to wetland forests. They are not considered to be a forest problem.

Destructive Rodents

Rats, mice, chipmunks, and rabbits or other rodents often destroy forest tree seeds, young trees, and important wildlife plants needed for other more valuable species. Ordinarily predators hold rodent populations in check, but rodent damage must be considered if any artificial regeneration for the improvement of timber stands or game holms is planned. Rodent control is not considered wildlife habitat research.

Rodents may become competitors to turkeys, quail, and other seed-eating birds, or to squirrels. Research work concerned with measures of utilization of food and forage should take proper precautions to prevent rodent use from confounding observations of utilization.

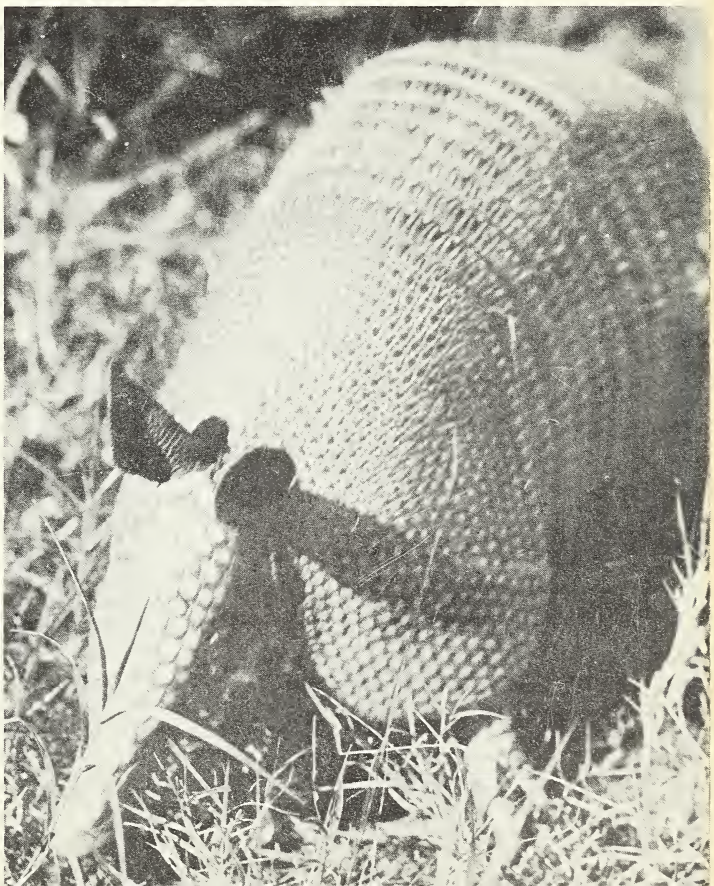
Armadillo

The armadillo is one of America's strangest animals. It is a mammal about the size of a cat, it has a long pointed nose, large ears, is covered by a jointed shell, and has a scaly pointed tail. Its young are born early in spring and the litters contain four young, always of the same sex.

The armadillo is found in Argentina, Central America, Mexico, and in isolated instances has been found as far north as Kansas and southern Illinois. It is common west of the Mississippi River and there are scattered colonies in the east Gulf States. One large expanding colony is found in east Florida (35, 80, 158, 215).

The food of the armadillo is primarily beetles, grasshoppers, moth larvae, millipedes, and small reptiles. Ants are eaten in large quantities--thousands of ants may be found in a single stomach. The armadillo also eats eggs of quail and other ground-nesting birds, together with melons and pine seeds (16, 17, 80).

Figure 3.--The armadillo is one of America's strangest animals.



At present no research is recommended as to the effect of the armadillo on forest game habitat.

Non-Game Birds

Non-game birds include such birds as buntings, the many different species of warblers and sparrows, hawks, owls, thrushes, wrens, woodpeckers, and many others that too often have been given no consideration because they could not be sold or eaten. Some have been killed off through wanton shooting by the legion of "sportsmen" who shoot at anything that moves. Almost as little consideration has been given to preserving the habitat of these many important birds. Habitat research should keep well informed as to the requirements of these birds and while present conditions do not indicate the need for special habitat studies, the effect of timber stand structure, season of burning, etc. on non-game birds should be noted. It may be that holms designed for such birds in their wintering or spring nesting grounds would be practicable. Trees having a mass of grapevines high in the crown are sometimes cut to bring the vines to the ground in reach of turkeys. It may also be important to leave some areas with grapevines high in trees to form nesting and feeding areas for non-game birds. Areas of heavy tangled growth without access trails might prove beneficial to birds.

PROBLEMS OF FOREST LAKES AND STREAMS

Although the primary emphasis in this analysis is upon upland forest game, the production of fish and other aquatic life must not be overlooked. It is for the biologist to determine which fish survive and develop best in the various waters and how they should be managed. However, the forester has the responsibility of managing so as to preserve good lake and stream conditions.

One of the forester's problems is to develop and maintain timber-cutting practices that reduce harmful sediments. Primary among these are the planning and installation of roads and stream crossings which will minimize the debris from roads and road banks and interfere as little as possible with the stream itself.

Another problem is the felling of timber into streams. While this usually is not serious, it may in some places disturb spawning grounds or impede normal flow of water by allowing debris to pile up and dam streams.

Figure 4.--Water plays a major role in the lives of game, forests, and vegetation. It also provides recreation, all-important in this day of shorter work hours and outdoor emphasis. (Photo by Louisiana Wild Life and Fisheries Commission)

Where summer temperatures are high, it is important that portions of forest streams and the edges of lakes be protected from direct sunlight. Excessive heating of the water causes biological disturbance which may be harmful to fish.

The effects of plant-killing chemicals on aquatic life are a common problem of the biologist and the forester. Particular attention must be paid to watershed requirements when dealing with combined timber, grazing, and wildlife management. Although no research is recommended now, much of the other work on general forest problems will have some bearing on forest lakes and streams. Research workers should be alert to these influences and point them out to management. Special problems may arise where research will be required.

SUMMARY OF RESEARCH NEEDS

This summary is prepared in outline form, and studies are listed under the following headings:

Wildlife food production and nutrient value
Forage utilization and condition and trend of vegetation
Range measurement techniques
Requirements of wildlife for food and cover
Integration of wildlife and timber management
Special measures for improvement of wildlife habitat
Wildlife damage to the forest
Competition between game animals and with livestock.

It is inevitable that under broad subjects, studies may relate to one or more headings; for example, range management techniques are used to determine forage utilization, and special measures to improve the habitat are designed to improve wildlife food production. However, these groupings are intended to segregate the suggested studies into somewhat similar fields.

The studies listed are not designed to become the titles of specific formal studies or of specific projects but are suggestive as to lines of investigation that are needed to answer some of the problems. Since this analysis covers so broad a territory, an investigator will find it necessary to determine the studies that are needed for his locality and to fit his work to the local condition.

The priorities under which the studies are listed are based primarily upon an opinion as to timing. That is, studies under A priority often may need to be done before B or C studies can be undertaken. This will not always be true, however, as the approach made by the individual investigator may alter these priorities altogether. The priorities as well as the studies should be considered as suggestions to be used as a checklist in formulating a local plan for wildlife habitat research.

Wildlife Food Production and Nutrient Value

Objective.--To measure yield, nutrient value, and the factors which influence the yield and nutrient value of wildlife food produced by the forest habitat.

Priority A

Deer forage production in relation to forest type and timber stand structure.
Mast production of trees to within known limits of error.
Application of mast yield of individual trees to animal carrying capacity on an areal basis.
Analysis and description of forage production capability of important forest-forage types.

Priority B

Seasonal variations in volume and nutrient value of key wildlife food species.
The effect of shade upon palatability, succulence, and nutrient content of selected game food species.

Priority C

Effect of interior boundaries between pine and hardwoods upon composition and growth of game food species in the pine-hardwood forests.
Winter reserves of squirrel food.
Carrying capacity of turkey range during critical periods.

Forage Utilization and Condition and Trend of Vegetation

Objective. --To measure and describe the utilization of forage plants in the important forest-forage types and to determine the effects of various degrees of utilization and seasons of use on the condition and trend of the vegetation.

Priority A

Seasonal variation in utilization of key forage plants by deer.
Utilization of key forage species by deer during the critical season in relation to condition and trend of the vegetation.
Development of criteria for determining trend of vegetation for the important forest-forage types.

Priority B

Effect of varying degrees of utilization on important forage plants, as determined by clipping.
Comparison of utilization of forage plants by deer, with and without mast available.
Utilization of key forage species in relation to soil and forest types.

Priority C

Phenological and physiological changes brought about by shading of key wildlife food species.
Utilization of forage in relation to prescribed burning in the forest.
Requirements of key game food plants for light, moisture, and soil fertility.
Comparison of utilization of forage by deer with and without supplemental feed.

Range Measurement Techniques

Objective. --To adapt or develop techniques for measuring the production of food and forage plants, their utilization by animals, and the trends in range condition resulting from animal use and from competition with other plants.

Priority A

Adaptation of methods to obtain an accurate measure of forage use by deer.

Development of guides by which deer and cattle utilization may be recognized on combined-use ranges.

Design of procedures for estimating mast production within known limits of error in terms of animal carrying capacity.

Comparison of an adaptation of a line transect method of measuring vegetation with the weight method on clipped plots in the Ozarks.

Priority B

Development of techniques for determining the carrying capacity of an area for squirrels.

Requirements of Wildlife for Food and Cover

The following problems are not forest habitat research, but are important biological questions which need to be solved by biologists before habitat research can make much progress. They are listed here to emphasize the close interdependence of research in animal biology and forest habitat. Because of the dependence of habitat research upon the answers to these biological problems, all are considered to be A priority.

Adaptability of selected wildlife species to changes in habitat brought about by various forest management practices.

Nutritional requirements of important wildlife species.

Response of animals to soil type.

Nutritional requirements of does in relation to breeding and fawn production.

Minimum requirements of important game species for supplemental feed in critical seasons.

The place of mast in the diet of deer and the response of deer to presence or absence of mast when adequate forage is available.

Adaptability of selected animals to changes in nesting or denning aspects of the habitat and need for den trees or den boxes or other artificial cover.

Procedures for estimating animal numbers within known limits of error.

Seasonal food habits of important game species.

Integration of Wildlife and Timber Management

Objective. --To determine how modification in the structure of the timber stand and in silvicultural practices will affect the occurrence, composition, volume, and quality of wildlife food and cover.

Priority A

Effects of various timber stand improvement practices upon total and seasonal production of wildlife food.

Ecological development of forage in relation to the growth and development of even-aged pine stands.

Effect of variations in timber stand structure upon the occurrence, composition, volume, and forage quality of grasses, forbs, and browse.

Effect of variation in timber stand structure upon the mast production of oaks of various species and age classes.

Effect of variation in timber stand structure upon production of pine seeds. (Should be corollary to forest management studies.)

Priority B

Effect of the size of area opened by timber harvest upon wildlife food production.

Analysis of timber management practices in terms of cost of game production measures.

Effect of various logging practices upon wildlife food and cover.

Effect of variation in timber stand structure upon the production of mast by understory trees like sumac, holly, and dogwood.

Priority C

Comparison of volume and nutrient value of forage produced under even-aged and all-aged management in pine types.

A comparison of long and short timber cutting cycles in relation to stability of wildlife populations.

Special Measures For Improvement of Wildlife Habitat

Objective. --To develop or test various methods of manipulating the forest habitat for the direct benefit of wildlife.

Priority A

Stimulation of growth of legumes in the forest understory.
Use of fertilizer in stimulating yield and improving nutrient value for selected wildlife food plants.
Artificial regeneration of selected native and introduced food plants for wildlife.
Use of logging roads and other artificial clearings as areas for producing wildlife food.
Selection and development of special mast-bearing forest trees (beech, Chinese chestnut, hazelnut, chinquapin, etc.)

Priority B

Selection and development of native understory trees (sumac, holly, dogwood, etc.) for wildlife food.
Use of chemical sprays in the development of wildlife food.
Comparison of game distribution and carrying capacity between forest areas without holms and with varying holm patterns.
Wildlife food production in relation to holm location and blackjack ridges, pine flats, and branch heads in the Coastal longleaf-slash pine types.
Cost of various types of game holms in terms of comparative timber production from similar areas.

Priority C

Effect of various types of prescribed burning upon wildlife food. (Normally should be corollary to prescribed-burning studies in silviculture.)
Management of wildlife holms to provide stages of succession complementary in game food to the surrounding forest.
Supplemental feeding as an aid in preserving the habitat during severe conditions.

Wildlife Damage to the Forest

Objective. --To study wildlife damage to the forest and to devise means of preventing or minimizing damage.

Priority A

Deer population and distribution in relation to season and severity of damage to natural forest reproduction.

Priority B

Methods of preventing deer grazing damage to seedlings.
Use of repellents on nursery stock to prevent damage to young plantations by deer.

Competition Between Game Animals and With Livestock

Objective. --To obtain a better understanding of the interrelations between the various animals using the forest habitat and to determine the effect of the competition between these animals upon the forest habitat.

Priority B

Effects of combined grazing by cattle and deer upon key forage plant communities.

Priority C

Hog-deer competition for oak mast.
Effects of woodlot grazing upon squirrel food.

Habitat Problems of Some Important Wildlife Species

Objective. --To obtain answers to some problems unique to certain species in their use of the forest habitat.

Priority A

Food preferences and forage utilization by known numbers of deer at various seasons and levels of grazing pressure.

Priority B

Wild turkey requirements in relation to potential turkey range.

Effect of various silvicultural practices upon turkey nesting and poult survival.

Effect of timber stand structure and silvicultural practices upon population and distribution of quail in the forest.

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